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GLATZ PROTOTYPE SEAT IMPACT TESTING

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Warfighter Interface Division
Applied Neuroscience Branch

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14. ABSTRACT
A series of dynamic tests with the Glatz prototype H-60 troop seat was performed to determine occupant protection during a crash event. These were re-tests of the Glatz prototype seat detailed in AFRL-RH-WP-TR-2012-0103. The re-tests were of Combined Vertical tests at which the Glatz prototype seat structurally failed during the initial study due to the manufacturer deviating from design drawings. A Pure Horizontal test was also conducted to determine structural strength of the Glatz prototype seat. Biodynamic response data were compared to standard injury criteria recommended by the Full Spectrum Crashworthiness Report as well as other seats tested at the same conditions. A total of eight tests were conducted. Additional manufacturing errors were found in several of the prototypes. The Glatz prototype seat structurally survived impact conditions at which it failed during the original troop seat comparison testing. Peak lumbar Z forces were higher for the Glatz prototype seat compared to other seats tested, and peak resultant chest accelerations were also generally higher than the other seats. While structurally successful, it appears the seat will require additional modifications to improve energy attenuation capability during a crash event. In the Pure Horizontal test, the seat structurally failed, suggesting that further redesign is necessary.

15. SUBJECT TERMS
H-60, troop seats, airbag restraint, H-60A/L, crashworthiness, crashworthy, helicopter, rotorcraft, occupant restraint

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PREFACE

This program was conducted by the Aerospace Biodynamics and Performance Research Team of the Applied Neuroscience Branch of the Human Effectiveness Directorate (711HPW/RHCP), under Workunit 53290811. Test support was provided by Infoscitex Corp. (IST) under contract FA8650-09-D-6949.

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1.0 INTRODUCTION

A recent study of 917 Class A and B Department of Defense (DoD) helicopter mishaps indicated that occupants of helicopter cargo compartments have a significantly greater chance of injury or death during a mishap than occupants in the cockpit (Mapes et al, 2007). The study discovered that vascular injuries to the chest were the leading cause of fatality in Class A helicopter mishaps, and that open skull fractures were the second. These two mechanisms of fatality were the most common compared to other causes such as injuries to the neck and extremities. The study also indicated that Navy SH-60B/F/H aircraft had a lower rate of cargo compartment injury and death, particularly from 1995 through 2005, when compared against other DoD helicopters from 1985 through 1994. This may have been due, in part, to the fact that the aircraft were originally outfitted with stroking, crashworthy seating. A finding from the Rotorcraft Survivability Study (2009) discovered that of 496 rotorcraft fatalities from October 2001 through December 2008, 97% of those fatalities occurred during the crash event.

The H-60 passenger protection system has been the gold standard of the DoD fleet. With a large number of helicopters in service and a robust mishap history, more is known about this system's injury history than most others. Improvements in survivability seen in the H-60 could be generalized to all helicopter forward/aft facing seating. While impact testing has been widely performed on ejection seats, only limited testing has been done on helicopter seating.

Based on these reports, the Neuroscience Branch (711 HPW/RHCP) agreed to conduct a dynamic comparative test program of currently-fielded and prototype troop seating for the H-60 Black Hawk and Pave Hawk rotorcraft. The test program consisted of impact testing of stock UH-60A/L, UH-60M seats, and prototype seats from Glatz Aeronautical (Newtown, PA) and Wolf Technical Services (Indianapolis, IN). The tests were conducted to compare how effectively the seats protected occupants ranging from the 5th percentile female to 98th percentile male. A series of ten tests using each type of seat was performed. Test orientations, manikins, and impact levels were based on MIL-S-85510(AS). In addition, impact levels at which currently-fielded H-60 troop seats were accepted for operational use were also considered. Results of this test program are documented in AFRL-RH-WP-TR-2012-0103.

During the seat testing program, structural failures of the Glatz prototype seat were observed. It is believed that some of these failures were due to manufacturing deviations from the design drawings. The Office of the Secretary of Defense, Deputy Director, Live Fire Test & Evaluation (OSD/DOT&E-LFT) agreed to fund re-testing of the Glatz prototype seat with properly manufactured seats at the test conditions where the seat structurally.

Testing was conducted under a Memorandum of Agreement (MOA) with the Defense Safety Oversight Council (DSOC) and OSD/DOT&E-LFT.

The comparative testing is experimental and not intended to qualify specific seats for acquisition. Consideration of the weight and cost of the seat was beyond the scope of this research effort. Test conditions were chosen to show crashworthiness protection at different levels and orientations. The methodology that was developed for this effort allows seating to be tested independent of airframes and could be used for the basis of performance testing prior to finalizing acquisition decisions. Comparative testing that is not dependent upon specific airframes allows direct comparison of the crashworthy properties of various seats developed at

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different times and with different technologies. Seating between different aircraft can be directly compared. The most effective structural and energy attenuator technologies can be identified and shared among rotorcraft and fixed-wing platforms using the defined test methodology.

This testing focuses solely on the survivability of the seat and occupant biodynamics during primary aircraft impact. Secondary injury effects, such as an occupant impacting other occupants, equipment, or aircraft structure are not considered in this study. Also, the ability of the occupant to egress the rotorcraft post-crash was not considered.

2.0 METHODS

2.1 Summary of Technical Approach

A series of short-duration impact acceleration tests were conducted with manikins representing a small female, average male, and large male. These were re-tests of the Glatz prototype seat at the same conditions used in AFRL-RH-WP-TR-2012-0103. The impact acceleration inputs to the seats were generated using the Horizontal Impulse Accelerator (HIA) and the Vertical Deceleration Tower (VDT). The experimental conditions varied as a function of seat orientation with respect to the impact vector, and as a function of impact amplitudes and durations.

Measurements included sled and carriage accelerations and velocity, seat accelerations, and manikin head, lumbar, and torso accelerations, forces, and moments. A specially designed test fixture to hold the seats in the various orientations during the impact was instrumented with load cells at the seat mounting points.

2.2 Glatz Aeronautical Prototype Seat

Glatz Aeronautical describes the prototype seats below:

> *The Glatz Aeronautical Corporation (GAC) prototype seat has been termed as the Next Generation Troop Seat (NGTS). It is an unconventional design that has limited hard structure and consists of a large foam seat pan with fabric side supports. The seat hangs from the H-60A/L upper seat attachments and has 1-inch webbing to secure the seat structure to the floor attachments.*
>
> *The unique design of the NGTS incorporates several novel theories to improve seat structural capability (stronger while being lighter) and provide occupant energy protection. The most important aspect is to provide occupant protection up to the full specification mishap severity requirement; something, current operational seats are unable to do. The NGTS is being designed such that the fatalities that would occur with a current operational seat will become no worse than a major injury. But, this has a trade-off: at mid-severity mishap levels, where a minor or major injury occurs with a current operational seat, the NGTS will yield a higher proportion of major injuries. To minimize and possibly mitigate this trade-off, additional occupant energy protection has been incorporated into the seat. This will require further study and development to ascertain its capability and effectiveness.*

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The NGTS has had several derivatives and variants. The first derivative of this seat was the Mrk1 which was developed to be a directly replaceable spare for H-60A/L aircraft. The next three variants were developed for an Air Force Research Laboratory (AFRL) Phase I Small Business Innovative Research (SBIR) program. These variants were developed to be generic and capable of installation in a wide range of rotary-wing aircraft. The three variants were tailored for each of the three existing specifications: Reduced Capability (RC) [Mrk4]; Full Capability (FC), Cabin [Mrk2]; and, Full Capability, Cockpit [Mrk3].

The original seat delivered for this comparative test effort was the Mrk5Mod1A. It is a derivative of the Mrk1 that incorporated lessons learned as a result of the SBIR program. The seat was modified during testing with stronger seat floor mounts and additional structure. This seat is called the Mrk5Mod1B.

The seats delivered for the re-tests are called the Mrk5Mod2A and incorporated many structural modifications from the 'lessons learned' during the first series of tests (including the additional occupant energy protection). During these re-tests the seat was further modified to improve the structural capability of the seat to transition energy into the upper attachments. This seat is called the Mrk5Mod2B. On the last test (VDT6291, Cell D), an additional seat structure was embedded in the Mrk5Mod2B seat structure. The embedded seat structure had its energy attenuation structure removed such that it would only react loads during a test where the Mrk5Mod2B had a catastrophic failure; which, it did. As a result of the failure of the upper attachment during this test, a further modification (Mrk5Mod2C) was fabricated which incorporated doubled-up snap hooks.

Originally, all seats were purchased new from GAC. During the test program several seats were modified, and GAC supplied additional seats, for tests. However, as can be seen from the various variants, the seat is in the developmental stage and does not represent a finalized design (Glatz 2013).

The Glatz seat is shown in Figure 1.

Figure 1. Glatz Aeronautical Prototype Seat

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2.3 Test Matrix

Figure 2 shows the coordinate system used to set up seat orientations as well as data channels. The “right-hand rule” coordinate system is used.

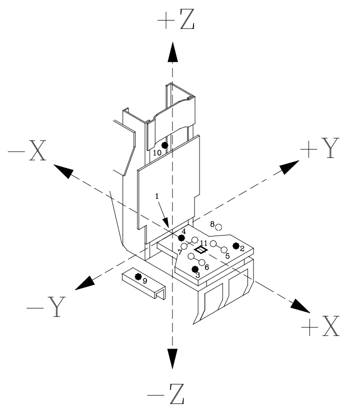

Figure 2. Coordinate system

Two different impact orientations were used in re-testing the Glatz prototype seat:

(1) Combined Vertical (CV) – 30 degree pitch forward, 10 degree roll relative to the positive z-axis acceleration pulse. The orientation is shown in Figure 2.

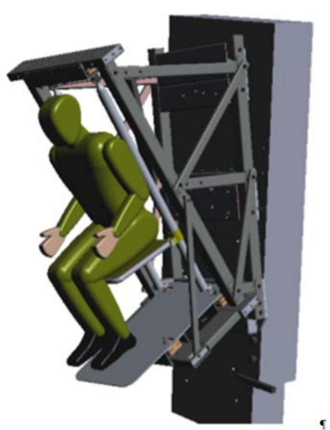

Figure 3. Combined Vertical Orientation

(2) Pure Horizontal (PH) – ‘eyeballs out’ orientation (manikin is facing the HIA thrust column). 0 degree yaw relative to the x-axis acceleration pulse. The PH orientation was completed using the HIA. (Figure 3)

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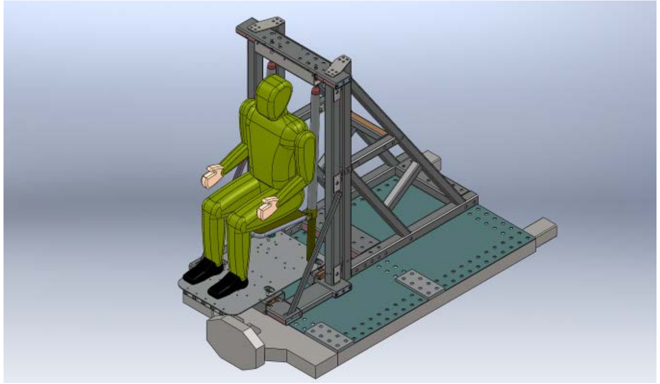
Figure 4. Pure Horizontal Orientation

Testing configurations were based on MIL-S-85510(AS) and previous testing of the legacy H-60A/L troop seat (Sikorsky Document SER-70102). It is noted that the rise times for the CV tests are roughly half of what is required to meet MIL-S-85510(AS). The experimental test matrix is summarized in Table 1. The “H-60 COMP Series” tests identified in the matrix are in reference to the tests conducted as part of the original test series documented in AFRL-RH-WP-TR-2012-0103. The “Glatz Series” tests identified in the matrix are the tests that were performed as part of the current test series. It should be noted that the accelerations recorded during Cell B and Cell D are lower than those documented in AFRL-RH-WP-TR-2012-0103. Using secondary accelerometers on the facility carriage and sled show that the energy input into the seat and manikin is consistent with the earlier testing, allowing for direct comparison.

Testing occurred over multiple dates with different variants of the seat. Each cluster of tests incorporated ‘lessons-learned’ from the previous round of tests to improve the structural integrity of the seat.

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Table 1. Test Matrix

Date	Series	Seat Variant	Test	Cell	Orientation	Manikin	G	Velocity
10 Jan 12	H-60 COMP	Mod1A	VDT6222	A	CV	LOIS	23.04	38.66
10 Jan 12	H-60 COMP	Mod1A	VDT6223	B	CV	LOIS	35.26	48.37
14 Feb 13	GLATZ	Mod2A	VDT6288	B	CV	LOIS	30.23*	48.14
11 Jan 12	H-60 COMP	Mod1A	VDT6226	C	CV	LARD	25.82	40.48
14 Feb 13	GLATZ	Mod2A	VDT6289	C	CV	LARD	25.39	40.54
1 Mar 13	GLATZ	Mod2B	VDT6290	C	CV	LARD	24.37	40.52
21 May 13	GLATZ	Mod2C	VDT6292	C2	CV	LARD	31.38	44.58
21 May 13	GLATZ	Mod2C	VDT6293	C3	CV	LARD	30.42	44.63
21 May 13	GLATZ	Mod2C	VDT6294	C4	CV	LARD	31.61	46.66
1 Mar 13	GLATZ	Mod2B	VDT6291	D	CV	LARD	33.05*	48.91
06 Feb 12	H-60 COMP	Mod1A	HIA8508	E	CH	LARD	18.05	46.15
08 Feb 12	H-60 COMP	Mod1B	HIA8510	E	CH	LARD	18.15	45.83
24 Jan 12	H-60 COMP	Mod1A	VDT6253	G	PV	LOIS	16.92	31.85
24 Jan 12	H-60 COMP	Mod1A	VDT6254	H	PV	LOIS	33.85	46.29
25 Jan 12	H-60 COMP	Mod1A	VDT6255	I	PV	LARD	15.94	30.89
25 Jan 12	H-60 COMP	Mod1B	VDT6256	J	PV	LARD	34.99	46.85
21 Feb 13	GLATZ	Mod2A	HIA8708	K	PH	HB50	18.63	47.39

*Issue with primary sled/carriage accelerometer, though energy input consistent with earlier testing

2.4 Facilities and Equipment

The 711HPW/RHCP HIA was used for all PH testing. The HIA consists of a 4 ft by 8 ft sled positioned on a 204 ft long track and is accelerated using a 24 inch diameter pneumatic actuator. The HIA operates on the principle of differential gas pressures acting on both surfaces of a thrust piston in a closed cylinder. The impact acceleration occurs at the beginning of the experiment as stored high-pressure air is allowed to impinge the surface of the metering pin attached to back of the thrust piston, thus causing the thrust piston to propel the sled away from the closed cylinder. As the sled breaks contact with the thrust piston, the sled coasts to a stop or is stopped with a triggered pneumatic brake system. The impact acceleration is roughly sinusoidal. HIA metering pin #52 was used for all cells.

The 711HPW/RHCP VDT was used for all CV tests. The VDT is a 40 ft gravity-assisted tower primarily used for simulation of the catapult phase of ejection. The VDT facility is composed of two vertical rails and a drop carriage. The carriage is allowed to enter a free-fall state (guided by the rails) from a pre-determined drop height. A plunger mounted on the rear of the carriage is guided into a cylinder filled with water located at the base of the tower between the vertical rails. A deceleration pulse is produced when water is displaced from the cylinder by the carriage-mounted plunger. The pulse shape is also roughly sinusoidal and is controlled by varying the drop height and shape of the plunger. VDT plunger #104 was used for all cells.

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During qualification testing, the mounting locations of the seats are often deformed to simulate deformation of an airframe during impact. For these comparison tests, it was determined that deformation of mounting points was not necessary.

2.5 Subjects

Tests were conducted with three different sized manikins including a Lightest Occupant in Service (LOIS) representing a small female, a 50th percentile Hybrid III Aerospace manikin (HB50) representing a mid-sized male, and a Large Anthropomorphic Research Device (LARD) manikin representing a large male. Both LOIS and LARD manikins are Hybrid III–type manikins that have been scaled to represent large and small occupants in the aerospace environment. LOIS and LARD are also used by the Air Force and Joint Strike Fighter (JSF) for ejection seat testing. Manikins were dressed in a flight suit and a medium ACH helmet. Weight distributions of the manikins are given in Table 2.

Table 2. Manikin Weight Distribution (lbs)

	LOIS	HB50	LARD
Upper torso	48.4	77.0	112.3
Lower Torso	48.8	83.0	119.8
Helmet, flight suit	5.3	4.7	9.6
Total	102.5	164.7	241.7

2.6 Data

Data were collected at 1,000 samples per second and filtered on-board the Data Acquisition System (DAS) using an 8-pole Butterworth filter at 120Hz. The filtering chosen has been demonstrated to be adequate for this type of comparison test program but is not necessarily consistent with filtering used during qualification testing. Table 3 lists the data channels collected. High-speed video of the test was taken at 1000 frames per second.

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Table 3. Data Channels

Carriage X, Y, and Z Acceleration (G)
Seat Fixture X, Y, and Z Acceleration (G)
Seat Pan X, Y, and Z Acceleration (G)
Top Left Seat Mount X, Y, and Z Force (LB)
Top Right Seat Mount X, Y, and Z Force (LB)
Bottom Left Front Seat Mount X, Y, and Z Force (LB)
Bottom Right Front Seat Mount X, Y, and Z Force (LB)
Bottom Left Rear Seat Mount X, Y, and Z Force (LB)
Bottom Right Rear Seat Mount X, Y, and Z Force (LB)
Left Torso Restraint Force (LB)
Right Torso Restraint Force (LB)
Left Lap Restraint Force (LB)
Right Lap Restraint Force (LB)
Internal Head X, Y, and Z Acceleration (G)
Internal Head Y Angular Acceleration (Radians/Sec^2)
Internal Upper Neck X, Y, and Z Force (LB)
Internal Upper Neck Moment X, Y, and Z Torque (IN-LB)
Internal Lower Neck X, Y, and Z Force (LB)
Internal Lower Neck Moment X, Y, and Z (IN-LB)
Internal Chest X, Y, and Z Acceleration (G)
Internal Chest Y Angular Acceleration (RAD/SEC^2)
Internal Lumbar X, Y, and Z Acceleration (G)
Internal Lumbar X, Y, and Z Force (LB)
Internal Lumbar Moment X, Y, and Z Torque (IN-LB)

The restraint instrumentation included in-line belt load cells (Figure 5). For several tests use of the lap belt load cells were not used as they would interfere with the restraint operation.

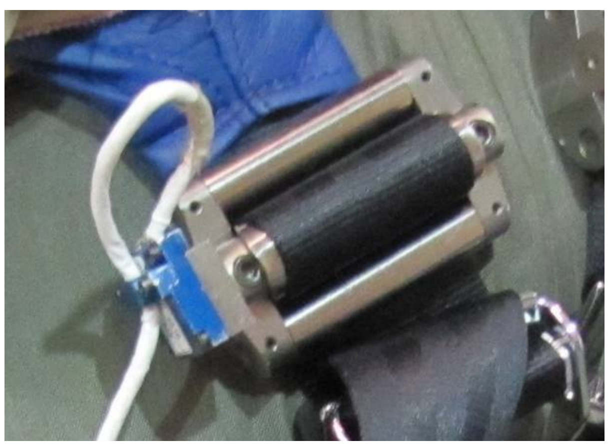

Figure 5. Restraint Belt Load Cell

The seat instrumentation included three linear accelerometers encapsulated in a disk that was taped to the top of the seat pan fabric just under the manikin's buttocks. This is seen in Figure 6.

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Figure 6. Seat Pan Accelerometer Pack

2.7 Test Procedures

Data channels were zeroed prior to placing the manikin into the seat. Once placed, the seat and restraint belts were pre-tensioned then to 20lbs +/- 5lb, when possible. The lap belts were tightened first to ensure the restraint buckle is as low as possible on the manikin's abdomen/pelvis. When possible, load cells on the lap belts were used to measure tension forces during impact. Due to the size of some of the manikins (primarily the LOIS and HB50) and length of the lap belts, the load cells on the lap belts were not used during all tests. This also prevented us from pre-tensioning the belts to 20lbs. In these cases the belts were essentially 'bottomed out' and were as tight as possible for the manikin tested. For reference, the 20lbs +/- 5lbs is borderline uncomfortable for human subjects. Laboratory testing is "best case" with regards to having the restraint tightened properly, and it is probably much tighter than how an operational user would wear their restraint based on experience and discussions with pilots. The helmet was placed on the manikin head and secured as tight as possible to prevent slippage.

On the VDT the carriage was raised to a pre-determined height to provide the required acceleration and velocity profile, and then dropped. On the HIA, the cylinder was pumped up to pre-determined pressures to match the desired acceleration and velocity profile. Post test and prior to the manikin being removed from the seat, the restraint buckle release loads were recorded.

2.8 Injury Criteria

The injury probability metrics used were primarily taken from the Full Spectrum Crashworthiness (FSC) report (Bolukbasi et al 2011) as it incorporates the most recent recommended criteria for troop seating. Injury criteria for head, neck, chest, lumbar, and extremities are included. Not all criteria from the FSC report are used because they did not apply to the test setup used. For instance, the Head Injury Criterion (HIC) was not used because the only aircraft structure simulated was the seat mounts and seat structure. Reporting of head-strike data could be misleading and irrelevant given the experimental setup used for this test series.

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Nij: For neck injury probability, Nij is used as it is the most accepted and validated criteria in the X-Z plane. The Nij value will be calculated throughout the time history of the impact test according to the following formula:

$$Nij = F/F_{int} + M/M_{int}$$

where:
F is the measured axial neck tension/compression or shear in pounds
F_{int} is the critical intercept load
M is the measured flexion/extension bending moment in in-lbs
M_{int} is the critical intercept moment

The Nij criteria do not apply to loading in pure tension or compression. Nij values are computed for each of the following combined loading cases:

N_{te} = Tension - Extension
N_{tf} = Tension - Flexion
N_{ce} = Compression - Extension
N_{cf} = Compression - Flexion

The critical intercept values for Nij calculation at C0-C1 for this program are based on the use of the manikins used in this program and are shown in Table 4.

Table 4. Intercept Values for Nij Calculation at C0-C1 for a Given Occupant Size

	Small Female Hybrid III Type Manikin	**Mid-Sized Male Hybrid III Type Manikin**	**Large Male Hybrid III Type Manikin**
Tension (lbs) (+F_z)	964	1530	1847
Compression (lbs) (-F_z)	872	1385	1673
Flexion (in-lbs) (+My)	1372	2744	3673
Extension (in-lbs) (-My)	593	1195	1584

Nij combines tension, compression, flexion, and extension of the upper neck to determine a probability of injury at a given injury level and is part of the JSF Neck Injury Criteria (NIC) (Nichols 2006). Though primarily developed and used in automotive environments, Nij thresholds have been modified for military personnel in aircraft environments for different occupant sizes. A Nij value of 0.5 correlates to a 10% probability of an Abbreviated Injury Scale (AIS) >=3 neck injury. Nij can be calculated for both upper and lower neck locations. Only upper neck Nij is reported for this program.

The Abbreviated Injury Scale (AIS) is an anatomical scoring system first introduced in 1969. Since that time it has been revised and updated against survival so that it now provides a reasonably accurate method of ranking the severity of injury. The latest incarnation of the AIS score is the 1990 revision. The AIS is monitored by a scaling committee of the Association for the Advancement of Automotive Medicine.

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Injuries are ranked on a scale of 1 to 6, where 1 is minor, 5 is severe, and 6 an un-survivable injury (Table 5). This represents the 'threat to life' associated with an injury and is not meant to represent a comprehensive measure of severity. The AIS is not a linear injury scale in that the difference between AIS 1 and AIS 2 is not the same as that between AIS 4 and AIS 5.

Table 5. Abbreviated Injury Scale Scores and Associated Injury

AIS Score	Injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Unsurvivable

A limitation of Nij is that it was developed primarily for +/-X accelerations and does not report off-axis injury probability. The Upper Neck Moment Index X (UNMIx) and Upper Neck Moment Index Z (UNMIz) were developed by the Navy to look at off-axis neck injury probability (Nichols 2006). These criteria are part of the JSF NIC and use both linear force and neck moments, just like Nij, to determine a neck injury probability. As a guideline an UNMIx or UNMIz value of 0.5 correlates to a 10% probability of a neck injury. Validation of the criteria has been limited; however, the UNMIx and UNMIz are reported in this study for comparison.

Restraint Loads: For chest injury probability, both chest acceleration and belt forces were collected during testing. The FSC Report recommends restraint belt force for injury probability. The criteria states that for one torso belt, the peak force must be less than 1750lb. For more than one torso restraint belt, the total peak force must be below 2000lb. All seats tested during this program utilized 4-point restraints, thus the 2000lb limit is most applicable. For the majority of testing, all four belts (left and right torso straps, left and right lap belt) were instrumented. However, lap belt force cells were not used during all tests due to the manikin fit within the seat, design of the seat, or length of available belts to instrument.

A chest resultant acceleration limit of 60G (Mertz 1989) for manikins is discussed within the FSC, though the FSC does not recommend its use. Instead, the FSC recommends use of the torso belt peak loads. The reason for this is that the torso belt loads and the chest resultant acceleration criteria should show similar results in some orientations. For this study the chest resultant accelerations are used because thoracic organ injury is caused by acceleration. Torso belt loading in the CV orientations do not show significant differences between the seat restraints tested.

Lumbar Loads: Lumbar injury probability is compared to limits derived by Desjardins (2008). The Desjardins lumbar force limits are based on 19.9 times the weight of a manikin above the lumbar load cell. For a 95% percentile Hybrid III male this correlates to a 1757lb compression limit. For the specific manikins used in this test program, the limits are 963.16lb for the LOIS (based on manikin weight above the lumbar load cell equal to 48.4lbs), 1532.3lbs for the HB50 (based on manikin weight above the lumbar load cell equal to 77lbs), and 2234.77lbs for the LARD (based on manikin weight above the lumbar load cell equal to 112.3lbs).

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A summary of the injury criteria used is in Table 6.

Table 6. Injury Criteria Used

	Recommended by FSC	Criteria Used	CV	PH
Neck	Nij	Nij	X	X
Chest	Belt Loads	Chest Accel Belt Loads	X X	X X
Lumbar	Peak Loads	Peak Load	X	X

3.0 RESULTS

A test-by-test description is given below.

VDT6288 – Cell B, CV, Mrk5Mod2A, LOIS, 30.23g, 48.14ft/s, 21.4ms rise time
VDT6288 is a retest of VDT6223. Pictures from the test are shown in Figures 7 and 8. The lap belt load cells were not used during the test as there was no additional belt length available due to the size of the manikin. The lap restraint was tightened as far a possible, though a pre-load was not possible. The seat structurally stayed intact during the test. There was no ripping of the seat seen post test. However, the manikin rebounded and 'bounced' up off the seat pan after the initial impact, causing a high chest acceleration with a peak of 82.42g and a lumbar Z force of 1469.94lbs, exceeding the lumbar load limit of 933lb compression limit. The restraint buckle came up into the chest of the manikin.

Figure 7. VDT6288 (L) Manikin position pre-test (R) Manikin rebound after initial pulse

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Figure 8. VDT6288 (L) Restraint Buckle post-test (R) Manikin position post test

VDT6289 – Cell C, CV, Mrk5Mod2A, LARD, 25.39g, 40.54ft/s, 29.3ms rise time

VDT6289 is a retest of VDT6226. Pictures from the test are shown in Figures 9, 10, 11, and 12. The lap belt load cells were usable with LARD. As the seat descended during the impact, the fabric on the upper right seat back ripped, and the spreader bars broke. The junction of the seat pan and the seat back ripped as well. However, the seat stayed attached to the fixture. As with VDT6288, the manikin rebounded after the initial pulse, though the resultant chest acceleration and peak lumbar Z force are within limits. It was decided not to continue testing with this version of the seat. After inspection of the seat, it is believed that there were deviations from the drawings supplied to the manufacturer that could have contributed to the structural failure of the seat.

Figure 9. VDT6289 (L) Manikin initial position (R) Seat ripping during test

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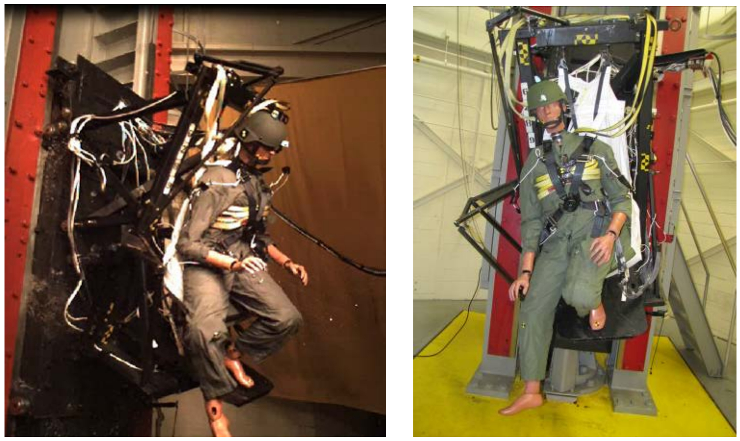

Figure 10. VDT6289 (L) Manikin rebound (R) Manikin post test

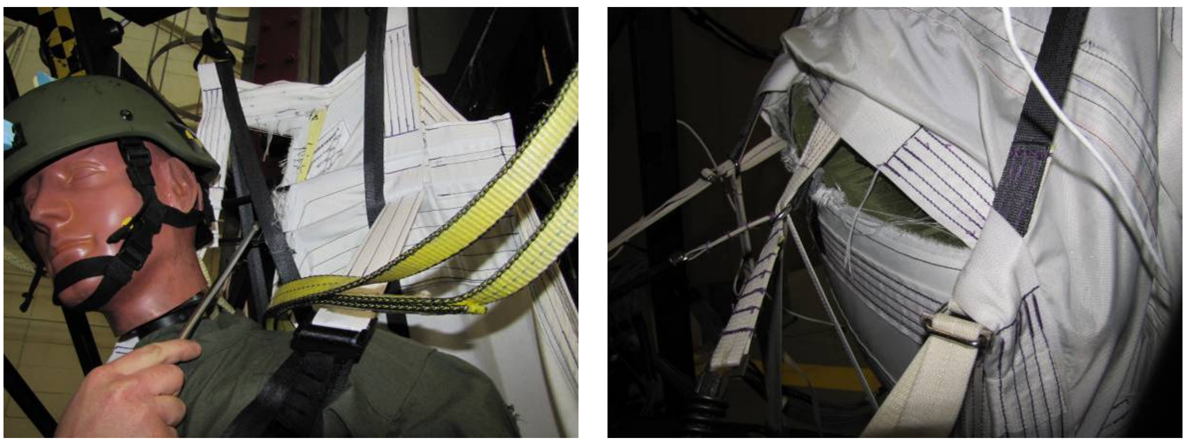

Figure 11. VDT6289 (L) Seat back ripping (R) Seat pan ripping

Figure 12. VDT6289 Spreader bar break

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VDT6290 – Cell C, CV, Mrk5Mod2B, LARD, 24.37g, 40.52ft/s, 28.3ms rise time
VDT6290 is a re-test of both VDT6226 and VDT6289. Pictures from the test are shown in Figures 13, 14, and 15. The seat structurally stayed intact during the impact, and all mounts remained attached to the fixture. There was some ripping of the stitching in the left spreader bar area. As with VDT6289 the manikin rebounded after the initial pulse, though the resultant chest acceleration and peak lumbar Z force are within limits.

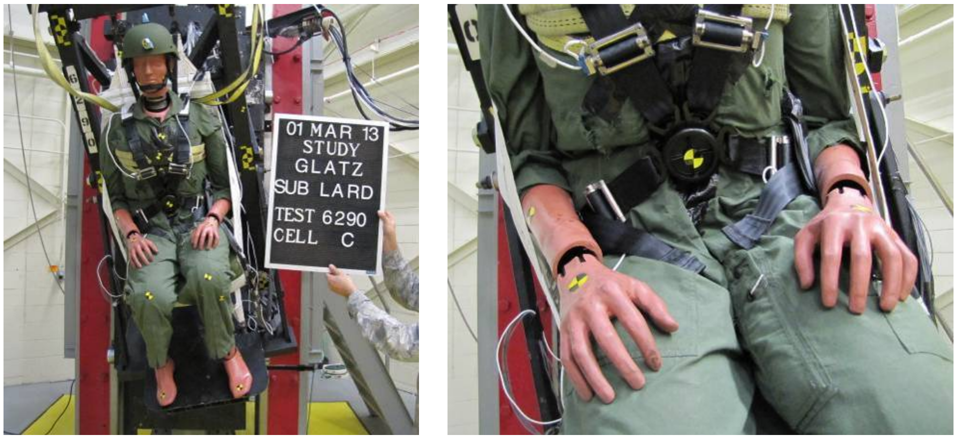

Figure 13. VDT6290 (L) Manikin initial position (R) Restraint

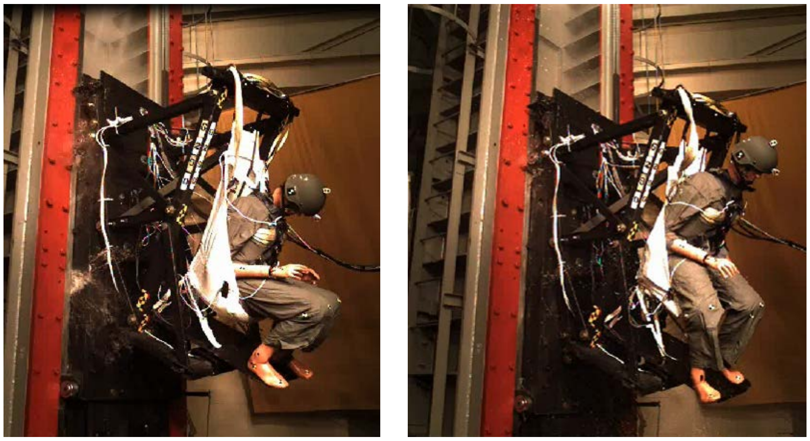
Figure 14. VDT6290 (L) Impact (R) Manikin rebound

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Figure 15. VDT6290 Manikin post test

VDT6291 – Cell D, CV, Mrk5Mod2B, LARD, 33.05g, 48.91ft/s, 24.6ms rise time

VDT6291 is the first Glatz test in Cell D. Pictures from the test are shown in Figures 16, 17, 18, and 19. One seat structure was embedded within another seat. Two upper attachment hooks were used on each side. During the impact one of the left upper attachment hooks broke. The manikin submarined out of the seat and was held by the restraints and safety tethers. Peak chest resultant acceleration was 57.09G, close to the limit of 60G. Peak lumbar Z force was 2045.31lb, below the limit of 2234.77lbs.

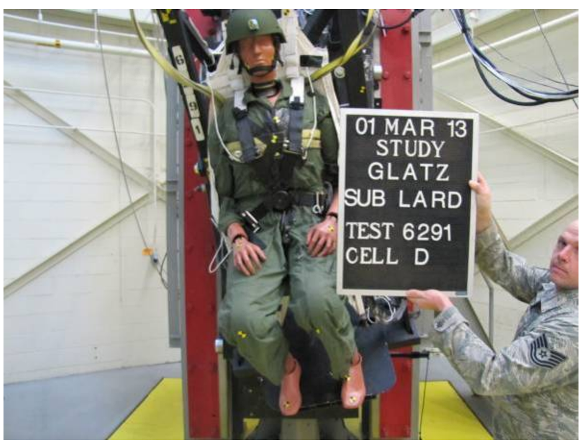

Figure 16. VDT6291 (L) Manikin initial position (R) Restraint

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Figure 17. VDT6291 (L) Double seat structure (R) Double hooks

Figure 18 VDT6291 (L) Manikin impact and seat rip (R) Manikin post test

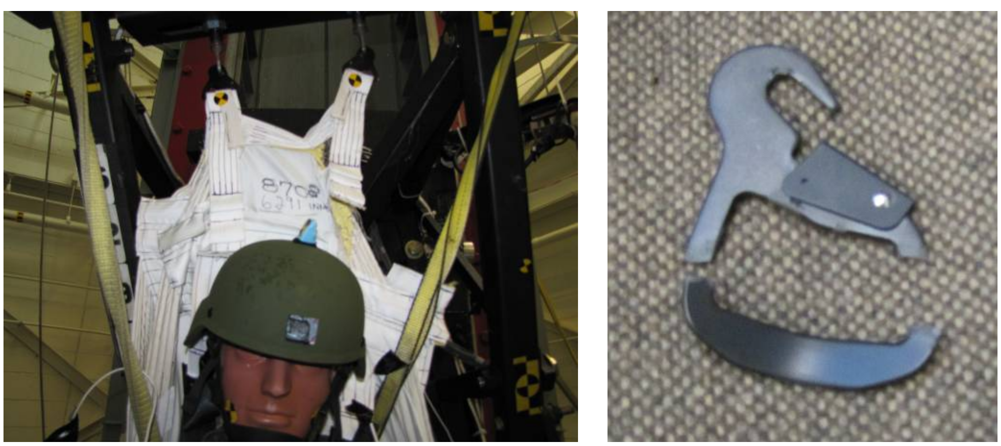

Figure 19. VDT6291 (L) Seat upper attachment (R) Broken upper attachment

VDT6292 – Cell C2, CV, Mrk5Mod2C, LARD, 31.48g, 44.58ft/s, 27.4ms rise time
VDT6292 used a remanufactured seat from test VDT6290. Pictures from the test are shown in Figure 20. The purpose of the test was to see how a remanufactured seat responded to a second

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crash pulse. As previous testing showed that the seat structurally survived at the ~26g pulse, an intermediate crash pulse between the 26 G and 36 G test was chosen. There was ripping of stitching by the upper left spreader bar, though the seat successfully restrained the manikin during the impact. The manikin swung from left to right while rebounding after the primary crash pulse. The manikin began to submarine out of the seat, though the restraint prevented the manikin from fully coming out of the seat. The chest resultant acceleration was 50.09g with a peak lumbar Z force of 1882.27lb. Both are within the injury criteria used for this program.

Figure 20. VDT6292 (L) Impact (M) Manikin final position (R) Ripping upper left

VDT6293 – Cell C3, CV, Mrk5Mod2C, LARD, 30.42g, 44.63ft/s, 26.1ms rise time

VDT6293 was the second test at the intermediate crash impact level. Pictures from the test are shown in Figures 21 and 22. The seat was a new seat and not one re-manufactured from a previously-tested seat. The manikin was successfully restrained in the seat during the test. As with VDT6292 the manikin began submarining in the seat, though the restraint successfully held the manikin during the impact. Rip stitching along the back and side of the seat pan successfully broke during the impact. The lap belts remained fixed to the seat structure. There was ripping of stitching close to the upper right spreader bars, though the seat successfully restrained the manikin during the impact. The peak chest resultant acceleration was 45.48g with a peak lumbar Z force of 1757.42lb. Both are within the injury criteria used for this program.

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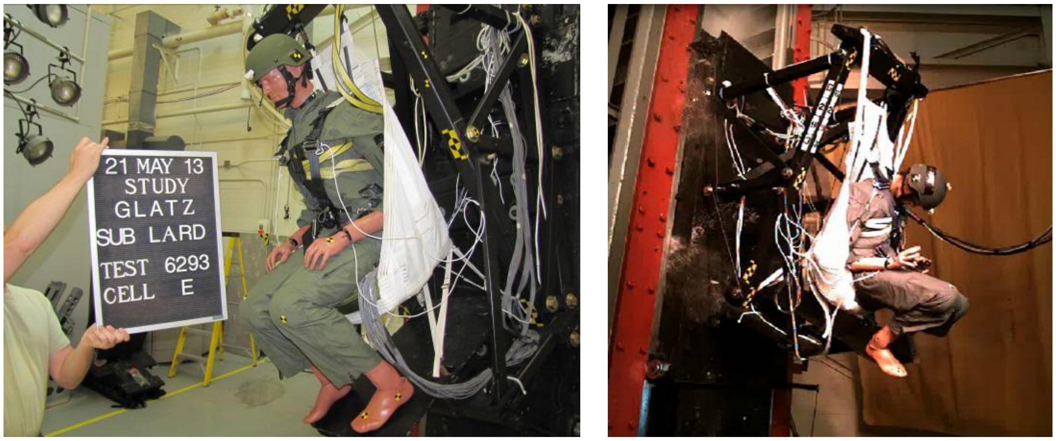

Figure 21. VDT6293 (L) Manikin pre-test, (R) Seat and manikin during test


Figure 22. VDT6293 (L) Manikin Post Test (R) Rip stitching on right seat pan


Figure 23. VDT6293 (L) Lap belt restraint post-test (R) Upper right stitching ripping

VDT6294 – Cell C4, CV, Mrk5Mod2C, LARD, 31.61g, 46.66ft/s, 25.9ms rise time
As the seat successfully held the manikin during VDT6291 and VDT6292, an intermediate crash impact level between Cell C3 and Cell D was chosen to determine structural integrity of the seat.

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Pictures from the test are shown in Figures 24, 25, and 26. The upper right portion of the seat close to the spreader bars broke. The manikin remained in the seat, though considerable rebound of the manikin was seen after the primary crash impact. Also, considerable submarining of the manikin was seen during the impact as the restraint buckle was forced into the manikin's abdomen and chest. The manikin's spine was out of position post-test. A peak chest resultant acceleration of 55.31g and a peak lumbar Z force of 2118.09lb were recorded. Both are within the established injury criteria used for this program.

Figure 24. VDT6294 (L) Manikin position pre-test (R) Manikin during impact

Figure 25. VDT6294 (L) Manikin swinging left to right during rebound (R) Manikin position post-test

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Figure 26. VDT6294 (L) Right lap belt post-test (R) Right upper ripping

HIA8708 – Cell U, PH, Mrk5Mod2A, HB50, 18.63g, 47.39ft/s, 73ms rise time
This HIA test was the only PH test conducted with the Glatz seat and the only test with a HB50 manikin. Pictures from the test are shown in Figures 27, 28, and 29. The test was conducted to determine structural integrity of the seat. The torso belts appear to detach during the impact, fully loading the lap belt. The lap belt completely detached from the seat structure, and the manikin was no longer restrained in the seat. The rear attachment webbing tensioners broke during the impact as the seat and manikin are pulled towards the front of the sled.

Figure 27. HIA8708 (L) Manikin initial position (R) Manikin flying off seat

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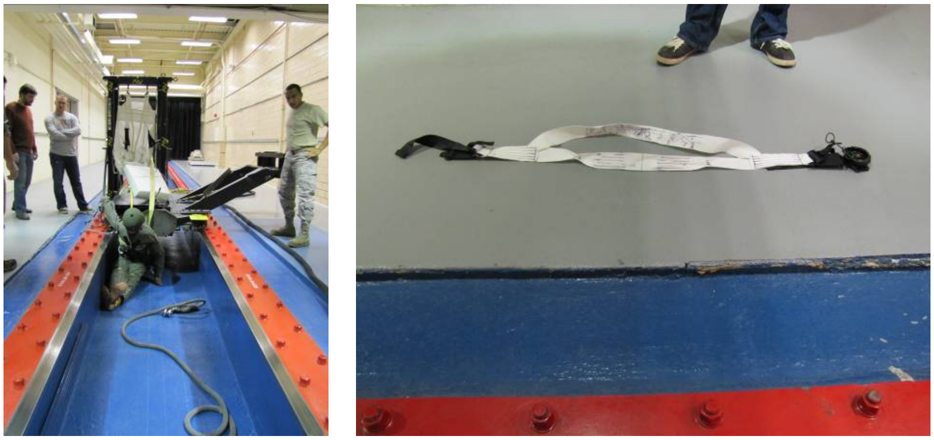

Figure 28 HIA8708 (L) Manikin position post test (R) Lap belt

Figure 29. HIA8708 Broken webbing tensioners

4.0 DISCUSSION

4.1 Combined Vertical Discussion

Table 7 summarizes predicted injury results for Cell B with both the original H-60 Comp data and the added Glatz prototype retest data. The retest data is highlighted at the bottom of the table. VDT6288 was an improvement over VDT6223 in that the Glatz prototype seat structurally survived the impact. The peak torso belt force resultant was one of the lowest measured among the seats tested. However, the peak chest resultant acceleration is considerably higher than that seen in the seats tested. The manikin 'rebound' in this re-test of the Glatz seat was significantly more dramatic than that seen in the other tests.

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Table 7. CV Cell B LOIS Injury Comparison Results

Test Series	Test #	Seat	Acceleration (G's)	Velocity (fps)	Structure	Torso Belts Peak Force (lb)	Chest Resultant G	Peak Lumbar Z
H-60 COMP	VDT6234	H-60A/L AFT	34.13	48.17	YES	79	33.71	810
H-60 COMP	VDT6220	H-60A/L FORE	35.70	48.29	YES	1351	29.34	1103
H-60 COMP	VDT6223	Glatz	35.26	48.37	NO	1138	46.89	1153
H-60 COMP	VDT6230	UH-60M	34.39	48.40	YES	1073	48.26	1484
H-60 COMP	VDT6232	Wolf	35.24	48.33	YES	906	53.34	2032
GLATZ	VDT6288	Glatz	30.23*	48.14	YES	698	82.42	1470

*Issue with primary sled/carriage accelerometer, though input conditions consistent with earlier testing

Table 8 summarizes the neck injury probability for Cell B with the original H-60 Comp and the added Glatz prototype retest data. Neck tension-flexion is exceeded with a value of 0.9922. Neck injury probably in tension-flexion appears to be consistent with the other seats.

Table 8. CV Cell B LOIS Neck Injury Comparison

Test Series	Test #	Seat	Acceleration (G's)	Velocity (fps)	Structure	Ntf	Nte	Ncf	Nce	UNMIx	UNMIz
H-60 COMP	VDT6234	H-60A/L AFT	34.13	48.17	YES	0.2509	0.0986	0.3114	0.1080	0.1898	0.0876
H-60 COMP	VDT6220	H-60A/L FORE	35.70	48.29	YES	0.9160	0.8704	0.2773	0.1893	0.2123	0.0747
H-60 COMP	VDT6223	Glatz	35.26	48.37	NO	1.0461	0.2787	0.2113	0.1987	0.4886	0.1381
H-60 COMP	VDT6230	UH-60M	34.39	48.40	YES	1.0650	0.5040	0.0466	0.4658	0.2258	0.0780
H-60 COMP	VDT6232	Wolf	35.24	48.33	YES	0.7707	0.6424	0.6909	0.3750	0.3407	0.0411
GLATZ	VDT6288	Glatz	30.23*	48.14	YES	0.9922	0.1383	0.3854	0.409	0.3275	0.0727

*Issue with primary sled/carriage accelerometer, though input conditions consistent with earlier testing

Table 9 summarizes the injury data for Cell C, incorporating the H-60 Comp data, the new Glatz prototype data, and data from the airbag restraint program with a modified H-60A/L seat. Even with the seat back fabric tearing, VDT6289 is a success in that it restrained LARD during the impact and the seat mounts remained attached. The load paths successfully kept the seat structurally intact. The torso belt loads and peak chest resultant acceleration are higher for

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VDT6289 than for VDT6290, potentially showing more movement of the seat and manikin with the seat back ripping. Both VDT6289 and VDT6290 have higher peak chest resultant acceleration and peak lumbar Z compression force than the other seats tested.

Table 9. CV Cell C LARD Injury Comparison Results

Test Series	Test #	Seat	Acceleration (G's)	Velocity (fps)	Structure	Torso Belts Peak Force (lb)	Chest Resultant G	Peak Lumbar Z
H-60 COMP	VDT6235	H-60A/L AFT	24.53	40.41	YES	71	28.90	564
H-60 COMP	VDT6224	H-60A/L FORE	25.47	40.51	YES	1034	19.49	929
H-60 COMP	VDT6226	Glatz	25.82	40.48	NO	2676		952
H-60 COMP	VDT6227	UH-60M	25.56	40.53	YES	1481	28.56	1346
GLATZ	VDT6289	Glatz	25.39	40.54	YES	1331	36.86	1711
GLATZ	VDT6290	Glatz	24.37	40.52	YES	922	42.40	1732
AIRBAG	VDT6287	H-60A/L w/crotch strap mod	21.39*	40.56	YES	1267	21.27	1373

*Issue with primary sled/carriage accelerometer, though input conditions consistent with earlier testing

Table 10 compares the neck injury criteria for Cell C with the original data, Glatz retest, and airbag restraint testing data. The neck injury data compares very well with the other seats tested.

Table 10. CV Cell C LARD Neck Injury Comparison Results

Test Series	Test #	Seat	Acceleration (G's)	Velocity (fps)	Structure	Ntf	Nte	Ncf	Nce	UNMIx	UNMIz
H-60 COMP	VDT6235	H-60A/L AFT	24.53	40.41	YES	0.0000	0.0456	0.0661	0.1721	0.1401	0.0697
H-60 COMP	VDT6224	H-60A/L FORE	25.47	40.51	YES	0.3379	0.0714	0.0287	0.1577	0.0818	0.0197
H-60 COMP	VDT6226	Glatz	25.82	40.48	NO	0.7638	0.2918	0.0184	0.1435	0.2105	0.1026
H-60 COMP	VDT6227	UH-60M	25.56	40.53	YES	0.4609	0.2260	0.0356	0.1724	0.1437	0.0558
GLATZ	VDT6289	Glatz	25.39	40.54	YES	Bad MY Channel					
GLATZ	VDT6290	Glatz	24.37	40.52	YES	0.24	0.066	0.0652	0.4	0.0657	0.0498
AIRBAG	VDT6287	H-60A/L w/crotch strap mod	21.39*	40.56	YES	Bad MY Channel					

*Issue with primary sled/carriage accelerometer, though input conditions consistent with earlier testing

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Table 11 summarizes the injury comparison data for Cell D with the original data, Glatz retest, and airbag restraint testing data with the H-60 seat. The Glatz prototype seat did not structurally survive the impact.

Table 11. CV Cell D LARD Injury Comparison Results

Test Series	Test #	Seat	Manikin	Acceleration (G's)	Velocity (fps)	Structure	Torso Belts Peak Force (lb)	Chest Resultant G	Peak Lumbar Z
H-60 COMP	VDT6236	H-60A/L AFT	LARD	35.90	48.82	YES	77	58.13	632
H-60 COMP	VDT6225	H-60A/L FORE	LARD	36.67	48.96	YES	1182	36.54	778
H-60 COMP	VDT6228	UH-60M	LARD	36.49		YES	1830		1284
GLATZ	VDT6291	Glatz	LARD	33.05*	48.91	NO	1676	57.09	2045
AIRBAG	VDT6284	H-60 Mod	LARD	28.56*	49.06	YES	1562	35.6	1579

*Issue with primary sled/carriage accelerometer, though input conditions consistent with earlier testing

Table 12 summarizes the neck injury probability data for Cell D. The probability of neck injury for the Glatz prototype seat is within established limits, though because the seat did not structurally survive, the data is irrelevant.

Table 12. CV Cell D LARD Neck Injury Comparison Results

Test Series	Test #	Seat	Acceleration (G's)	Velocity (fps)	Structure	Ntf	Nte	Ncf	Nce	UNMIx	UNMIz
H-60 COMP	VDT6236	H-60A/L AFT	35.90	48.82	YES	0.0634	0.0481	0.3350	0.0801	0.2070	0.1058
H-60 COMP	VDT6225	H-60A/L FORE	36.67	48.96	YES	0.5494	0.1943	0.0712	0.1847	0.0710	0.0548
H-60 COMP	VDT6228	UH-60M	36.49		YES	0.7564	0.2927	0.0374	0.1973	0.2160	0.0680
GLATZ	VDT6291	Glatz	33.05*	48.91	NO	0.4073	0.1272	0.3944	0.0086	0.1094	0.0649
AIRBAG	VDT6284	H-60 MOD	28.56*	49.06	YES	0.5855	0.1412	0.0311	0.2368	0.1603	0.0791

*Issue with primary sled/carriage accelerometer, though input conditions consistent with earlier testing

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Cells C2, C3, and C4 are not directly comparable to any other Cells or any of the other seat tests. The purpose of the Cells were to determine structural integrity of the seat between impact levels at which the seat was known to structurally survive and successfully restrain an occupant (Cell C) and a level at which the seat was known not to survive and not restrain an occupant (Cell D). Structural integrity of the seat was demonstrated through Cell C4, though it is unknown if the Mod2C seat would survive the Cell D crash impulse. Improved structural integrity of the seat was seen during these tests compared to the earlier tests.

4.2 Pure Horizontal Comparison

Table 13 summarizes the injury comparison data for Cell D with the Glatz retest and the airbag restraint testing with the H-60 seat. No PH tests were completed in the original test program. The only seat that remained structurally intact was the modified H-60 seat.

Table 13. PH Cell U HB50 Injury Comparison Results

Test Series	Test #	Orientation	Seat	Acceleration (G's)	Velocity (fps)	Structure	Torso Belts Peak Force (lb)	Chest Resultant G	Peak Lumbar Z
GLATZ	HIA8708	PH	Glatz	18.63	47.39	NO	1977	18.23	1162
AIRBAG	HIA8621	PH	H-60A/L	17.89	46.1	NO	1827	28.55	1827
AIRBAG	HIA8704	PH	H-60A/L w/crotch mod	18.01	46.73	NO	2025	30.58	603
AIRBAG	HIA8705	PH	H60A/L w/crotch mod 2	18.2	46.53	YES	2060	23.60	325

Table 14 summarizes the neck injury probability data for Cell U. All seats surpassed the established injury criteria for tension-flexion. The modified seat was the only seat within the criteria.

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Table 14. PH Cell U HB50 Neck Injury Comparison Results

Test Series	Test #	Seat	Acceleration (G's)	Velocity (fps)	Structure	Ntf	Nte	Ncf	Nce	UNMIx	UNMIz
GLATZ	HIA8708	Glatz	18.63	47.39	NO	0.57	0.3456	0.187	0.3135	0.1089	0.045
AIRBAG	HIA8621	H-60A/L	17.89	46.1	NO	0.6923	0.4135	0.2941	0.0719	0.1102	0.0825
AIRBAG	HIA8704	H-60A/L w/crotch mod	18.01	46.73	NO	0.7379	0.1765	0.2267	0.3551	0.0891	0.032
AIRBAG	HIA8705	H60A/L w/crotch mod 2	18.2	46.53	YES	0.4435	0.237	0.1344	0.099	0.0781	0.0368

4.3 General Observations

There were structural improvements to the Glatz prototype seats versus the seats originally tested. For cells at which the originally-tested seats failed, Cell B and Cell C, the modified Glatz prototype seats structurally survived the impacts. However, it does not appear that the seats attenuated much energy transferring to manikin during the impact. With the rebound of the manikin post-impact, the seat may have amplified the energy transmitted into the manikin. Second, submarining of the manikin in the seat during the CV tests was still apparent at the higher energy levels. This appears to be consistent with the H-60A/L and UH-60M seats tested, and is most likely a function of the 4-point restraint. Cells C2, C3, and C4 (with the Mod2C variant) demonstrated structural strength of the Glatz seat at crash impacts more severe than levels previously tested.

The Glatz prototype seats have not demonstrated structural strength in a primarily horizontal impact. Redesign of how the restraints are attached to the seat structure is necessary.

5.0 CONCLUSION

A series of dynamic tests with the Glatz prototype H-60 troop seat was performed to determine occupant protection during a crash event. These were re-tests of the Glatz prototype seat from an earlier troop seat comparison study. The re-tests were of Combined Vertical tests at which the Glatz prototype seat structurally failed during the previous study due to the manufacturer deviating from design drawings. A Pure Horizontal test was also conducted to determine structural strength of the Glatz prototype seat. Acceleration, force, and moment biodynamic response data were compared to standard injury criteria recommended by the Full Spectrum Crashworthiness Report. Injury data were compared to other seats tested at the same conditions. A total of eight tests were conducted. Additional manufacturing errors were found in several of the prototypes. The Glatz prototype seat structurally survived impact conditions at which it failed during the original troop seat comparison testing. Peak lumbar Z forces were higher for the Glatz prototype seat compared to other seats tested, and peak resultant chest accelerations were also generally higher than the other seats. While structurally successful, it appears the seat

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will require additional modifications to improve energy attenuation capability during a crash event. In the Pure Horizontal test, the seat structurally failed, suggesting that further redesign is necessary.

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ACRONYM

711HPW	711th Human Performance Wing
ACH	Advanced Combat Helmet
AFRL	Air Force Research Laboratory
AIS	Abbreviated Injury Scale
CV	Combined Vertical
CH	Combined Horizontal
DOT&E	Office of the Director, Operational Test & Evaluation
DRI	Dynamic Response Index
DRMO	Defense Reutilization and Marketing Offices
DRZ	Dynamic Response Index Z
DSOC	Defense Safety Oversight Council

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FSC	Full Spectrum Crashworthiness
HIA	Horizontal Impulse Accelerator
HIC	Head Injury Criterion
JSF	Joint Strike Fighter
LARD	Large Anthropomorphic Research Device
LOIS	Lightest Occupant In Service
MOA	Memorandum of Agreement
NIC	Neck Injury Criteria
OSD	Office of the Secretary of Defense
PV	Pure Vertical
SBIR	Small Business Innovative Research
UNMIx	Upper Neck Moment Index X
UNMIz	Upper Neck Moment Index Z
VDT	Vertical Deceleration Tower

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Appendix A. Injury Criteria Results

Program	Test #	Cell	Orientation	Seat	Seat Variant	Manikin	Acceleration (G's)	Velocity (fps)	Structure	Torso Belts Peak Force (lb)	Chest Resultant G	Peak Lumbar Z	Ntf	Nte	Ncf	Nce	UNMIx	UNMIz
H-60 COMP	VDT6222	A	CV	GLATZ	Mod1A	LOIS	23.04	38.66	YES	700	40.66	1019	0.4641	0.1370	0.0613	0.2228	0.2051	0.0607
H-60 COMP	VDT6234	B	CV	H-60A/L AFT		LOIS	34.13	48.17	YES	79	33.71	810	0.2509	0.0986	0.3114	0.1080	0.1898	0.0876
H-60 COMP	VDT6220	B	CV	H-60A/L FORE		LOIS	35.70	48.29	YES	1351	29.34	1103	0.9160	0.8704	0.2773	0.1893	0.2123	0.0747
H-60 COMP	VDT6223	B	CV	Glatz	Mod1A	LOIS	35.26	48.37	NO	1138	46.89	1153	1.0461	0.2787	0.2113	0.1987	0.4886	0.1381
H-60 COMP	VDT6230	B	CV	UH-60M		LOIS	34.39	48.40	YES	1073	48.26	1484	1.0650	0.5040	0.0466	0.4658	0.2258	0.0780
H-60 COMP	VDT6232	B	CV	Wolf		LOIS	35.24	48.33	YES	906	53.34	2032	0.7707	0.6424	0.6909	0.3750	0.3407	0.0411
GLATZ	VDT6288	B	CV	Glatz	Mod2A	LOIS	30.23	48.14	YES	698	82.42	1470	0.9922	0.1383	0.3854	0.409	0.3275	0.0727
H-60 COMP	VDT6235	C	CV	H-60A/L AFT		LARD	24.53	40.41	YES	71	28.90	564	0.0000	0.0456	0.0661	0.1721	0.1401	0.0697
H-60 COMP	VDT6224	C	CV	H-60A/L FORE		LARD	25.47	40.51	YES	1034	19.49	929	0.3379	0.0714	0.0287	0.1577	0.0818	0.0197
H-60 COMP	VDT6226	C	CV	Glatz	Mod1B	LARD	25.82	40.48	NO	2676		952	0.7638	0.2918	0.0184	0.1435	0.2105	0.1026
H-60 COMP	VDT6227	C	CV	UH-60M		LARD	25.56	40.53	YES	1481	28.56	1346	0.4609	0.2260	0.0356	0.1724	0.1437	0.0558
GLATZ	VDT6289	C	CV	Glatz	Mod2A	LARD	25.39	40.54	NO	1331	36.86	1711	Bad MY Channel					
GLATZ	VDT6290	C	CV	Glatz	Mod2B	LARD	24.37	40.52	YES	922	42.40	1732	0.24	0.066	0.0652	0.4	0.0657	0.0498
GLATZ	VDT6292	C2	CV	Glatz	Mod2C	LARD	31.38	44.58	YES	1093	50.09	1882	0.3591	0.2672	0.0263	0.3320	0.1256	0.0350
GLATZ	VDT6293	C3	CV	Glatz	Mod2C	LARD	30.42	44.63	YES	1318	45.48	1757	0.3906	0.1174	0.0312	0.3104	0.8474	0.0576
GLATZ	VDT6294	C4	CV	Glatz	Mod2C	LARD	31.61	46.66	YES	Bad Right	55.31	2118	0.4327	0.2641	0.0289	0.3524	Bad MX	0.0546
AIRBAG	VDT6287	O	CV	H-60A/L w/crotch mod		LARD	21.39	40.56	YES	1267	21.27	1373	Bad MY Channel					
H-60 COMP	VDT6236	D	CV	H-60A/L AFT		LARD	35.90	48.82	YES	77	58.13	632	0.0634	0.0481	0.3350	0.0801	0.2070	0.1058
H-60 COMP	VDT6225	D	CV	H-60A/L FORE		LARD	36.67	48.96	YES	1182	36.54	778	0.5494	0.1943	0.0712	0.1847	0.0710	0.0548
H-60 COMP	VDT6228	D	CV	UH-60M		LARD	36.49		YES	1830		1284	0.7564	0.2927	0.0374	0.1973	0.2160	0.0680
AIRBAG	VDT6284	Q	CV	H-60MOD		LARD	28.56	49.06	YES	1562	35.6	1579	0.5855	0.1412	0.0311	0.2368	0.1603	0.0791
GLATZ	VDT6291	D	CV	Glatz	Mod2B	LARD	33.05	48.91	NO	1676	57.09	2045	0.4073	0.1272	0.3944	0.0086	0.1094	0.0649
H-60 COMP	HIA8508	E	CH	Glatz	Mod1B	LARD	18.05	46.15	NO	1815	20.23		0.7249	0.6245	0.0479	0.0378	0.2435	0.1679
H-60 COMP	HIA8510	E	PV	Glatz	Mod1B	LARD	18.15	45.83	NO		24.17		0.5782	0.5351	0.6137	0.2861	0.3053	0.0770
H-60 COMP	VDT6253	G	PV	Glatz	Mod1B	LOIS	16.92	31.85	YES	129	26.22	939	0.1824	0.0788	0.4479	0.1740	0.1131	0.0285
H-60 COMP	VDT6254	H	PV	Glatz	Mod1B	LOIS	33.85	46.29	YES	277	53.99	1360		0.2448	0.4907	0.4014	0.2136	0.0406
H-60 COMP	VDT6255	I	PV	Glatz	Mod1B	LARD	15.94	30.89	YES	415	26.19	897	0.0155	0.0717	0.1713	0.2894	0.0359	0.0187
H-60 COMP	VDT6256	J	PV	Glatz	Mod1B	LARD	34.99	46.85	YES	493	44.34	1251	0.1404	0.0779	0.1843	0.3474	0.1519	0.0332
GLATZ	HIA8708	U	PH	Glatz	Mod2A	HB50	18.63	47.39	NO	1977	18.23	1162	0.57	0.3456	0.187	0.3135	0.1089	0.045
AIRBAG	HIA8621	C	PH	H-60		HB50	17.89	46.1	NO	1827	28.55	1827	0.6923	0.4135	0.2941	0.0719	0.1102	0.0825
AIRBAG	HIA8704	U	PH	H-60A/L w/crotch mod		HB50	18.01	46.73	NO	2025	30.58	603	0.7379	0.1765	0.2267	0.3551	0.0891	0.032
AIRBAG	HIA8705	U	PH	H-60A/L w/crotch mod 2		HB50	18.2	46.53	YES	2060	23.60	325	0.4435	0.237	0.1344	0.099	0.0781	0.0368

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